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NYLON

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On October 27, 1938, du Pont announced to the world the development of a group of synthetic superpolymers from which, among other possible applications, textile fibers could be spun, surpassing in strength and elasticity any previously known textile fiber, whether cotton, linen, wool, silk, or rayon.

The word "nylon" has no etymological significance. When the polyamides were developed, it was apparent to the duPont Company that no short, "catchy" word existed by which this new group of synthetic materials could be designated. Therefore, much thought was given to the coining of a non-technical, generic name for the polyamides. Since rayon and cotton both end with the letters "on", it was felt desirable that the new word end in "on". After much deliberation, the term "nylon" was finally adopted.

Nylon is officially and scientifically defined as "a man-made protein-like chemical product (poly amide) which may be formed into fibers, bristles, sheets, and other forms which are characterized when drawn by extreme toughness, elasticity, and strength."

From this definition, it follows that nylon does not refer simply to the fibers or yarn spun from a poly amide, as many thought, but rather to the poly amide itself from which fibers, bristles, sheets, etc., may be formed.

One of the simplest ways of making the nylon superpolymer involves the reaction of a dibasic acid,

of which there are many, with an organic diamine. This reaction, which results in the formation of relatively small molecules, is followed by heating, which brings about the union of many of these small molecules to give the giant molecules.

A simple analogy may help to explain how one kind of giant polyamide molecule is formed.

Let us think of the dibasic acids and diamines as short chains with hooks at each end. Pursuing this analogy, let us suppose that every little acid chain has a red hook at each end, and every little diamine chain has a blue hook at each end. Let us further suppose that a red hook cannot unite with another red hook, nor a blue hook with another blue hook,—but that, when heated together, red hooks are anxious to unite with blue hooks.

In such case it is easy to see that when a dibasic acid with its red hooks is added to a diamine with its blue hooks, and that mixture is heated, the red hook at one end of a dibasic acid chain might unite with the blue hook at one end of a diamine chain, to give a somewhat larger chain made up of one dibasic acid molecule and one diamine molecule. But since the original dibasic acid chain has a red hook at each end, and the original diamine chain a blue hook at each end, it is clear that the new chain made by the union of one dibasic acid molecule with one diamine molecule would have an empty or unused red hook



at one end, and, similarly, an empty blue hook at the other end.

It follows, therefore, that the red hook at one end of this dibasic acid-diamine chain might unite with the blue hook at the end of another such chain,—and so on until a very long chain had been formed.

This is, in effect, what happens when a dibasic acid and a diamine are heated together. The polyamide superpolymers made from a dibasic acid and a diamine are known as nylon.

It was indicated above that the polyamide chain might be infinitely long. In actual practice, however, the polyamide chains in nylon are not of infinite length, as is theoretically possible, but, by proper control of the reaction, are purposely limited to length in order that the nylon may have the desired physical qualities for proper mechanical processing.

Viscosity measurements of dilute solutions of one type of nylon in mecresol indicate an approximate average molecular weight of 12,500 corresponding to 920 units per polymer chain.

Until recently, nylon was produced on a small scale in a "pilot" plant at the du Pont Experimental Station in Wilmington, Delaware, but this plant has a very limited daily capacity and the yarn is used almost exclusively for experimental purposes. Nylon for the large monofilaments which are being used as bristles, surgical sutures, and fishing leaders is also being supplied by this pilot plant.

In addition, extensions costing \$2,500,000 have been made to the du Pont Ammonia Department plant at Belle, West Virginia to provide facilities for making nylon intermediates; and a plant for the commercial production of nylon was completed recently in Seaford, Delaware at a cost of \$8,500,000.⁵ Production of nylon on a commercial scale is now under way. The Seaford plant will have a capacity of approximately 4,000,000 pounds of nylon yarn per year. Nylon flake for monofilament purposes (bristles, surgical suture, etc.), as well as for other possible applications, will also be produced at Seaford.

Since one of the major outlets for nylon will be yarn suitable for hosiery and other textiles, it may be of importance to outline the process by which nylon yarn is made.

The nylon in molten form is forced through a spinneret, and the filaments formed instantly freeze,—that is, become solid. The filaments from one spinneret are wound upon a suitable device, and later given a few turns per inch to facilitate further handling. In brief, the process from this point on involves: stretching the bundles of fibers, now known as yarn, to the desired degree; applying a "size" or lubricant, or both, to facilitate knitting or weaving; and packaging the yarn in the form of skeins, "cones" or other forms suitable for shipping.

Drawing the yarn to the desired degree is carried

out as follows. If the yarn in question is to be stretched to four times its original length, it is unwound from one spool onto another in such a way that it is subjected to a four-fold stretch during the unwinding-rewinding operation. This is accomplished by winding the yarn at a rate four times that of the unwinding rate.

The size of individual nylon filaments is determined by controlling the rate of delivery from the pump and by the rate at which the yarn is drawn away from the spinneret. The size of the yarn after stretching is dependent upon its original size and the degree of cold drawing. If it is drawn to four times its original length, the stretched yarn is only one-half its original diameter.

Nylon yarn, as normally made, has a high luster, but, by adding to the molten polymer before it is spun, a finely divided white pigment, such as TiO_2 , yarn with the desired degree of dullness may be obtained. Since this dullness is due to pigment particles *within* the filaments, and not simply on the surface, the dullness is not affected by subsequent wear or washing.

Once a nylon fabric has become set, a condition of heat and moisture more severe than the condition of set is necessary in order to effect a resetting in another shape. Therefore, nylon stockings are given a preliminary set known as "pre-boarding" in the desired shape immediately after knitting. Since pre-boarding is the first hot wet treatment in the sequence of manufacture, it determines in large degree the permanent shape and smoothness of the stockings. Because the effects of the setting are practically permanent, the stockings may be laundered and dried repeatedly without material change in their original shape and smooth appearance.

Some of the patents held by du Pont cover the use of polyamide yarn for stockings, setting yarns, and fabrics, and the use of sodium sulphite for setting.

The surgical technique of closing wounds and ligating hemorrhages with threads of varying composition had its crude beginning in the prehistoric past. Galen, in the first century, mentions the use of silk. An interesting fact is that while manufacturing and processing have made giant strides, base materials for present day sutures have been essentially unchanged in two thousand years,—that is, unchanged until the magic of modern chemistry produced a significantly different suture material, nylon.

Characteristics of nylon sutures include low tissue tolerance (the ability of suture to remain in place during implantation with no adverse chemical or physiological effects on surrounding tissues), and it is also non-capillary (takes up little water and presents no surface interstices such as silk does for wound tissue to grow into during healing.)

For centuries, Nature's best material for bristles,

such as those used in toothbrushes, has been hog bristles. With only the swine living in cold regions such as Siberia, Poland, or inland China growing bristles sufficiently long, tough, and resilient for the toothbrush; it is particularly fortunate that nylon bristles come at this time.

With the trade in bristles from Russia, China, and Poland having almost stopped as a result of war conditions, nylon has had the real opportunity of being used on a rather large commercial scale as the bristling filaments in a prominent brand of toothbrushes. Millions of the brushes have been made, and results indicate that the "Exton" bristle will wear from two to three times as long as natural bristles.

Qualifications which make "Exton" bristles well adapted for such use are:

It can be made uniformly in any required gauge.

Its color is clean, uniform, and permanent.

Its water absorption is much lower than that of the natural bristle.

Its durability is far greater than that of natural bristle: it does not, for example, split like hog bristle.

It is clean and sterile due to the method of manufacture.

Besides being used for stockings, and for surgical sutures, nylon is being used commercially as fishing line, fishing line leaders and sewing thread. A proposed use is in the making of parachutes.

Since nylon is not one particular polyamide, but rather a family of related polyamides, it might be expected that various raw materials could be used in

making various types of nylon, and such is the case. One particular type which now appears quite promising for making textile yarns can be made from a dibasic acid derived from phenol, and a diamine likewise derived from phenol. Oxygen from the air is also needed in making the dibasic acid, and ammonia is used in making the diamine. Since phenol is commonly derived from bituminous coal, and since ammonia is made synthetically by causing the hydrogen from water to unite with nitrogen from the air, it follows that this particular nylon is derivable from coal, air, and water. Other types of raw materials might be used to advantage in making other types of nylon. For example, one type which has been found useful for certain purposes involves the use of a dibasic acid derived from a vegetable oil. It is thus evident that agricultural raw materials as well as mineral raw materials may enter into the manufacture of nylon.

While it is of economic and industrial significance that nylon can be made from domestic raw materials such as coal, air, and water, of which this country has an abundance, it should be pointed out that this is only a part of the story.

The layman may sometimes wonder why a product based on cheap and abundant raw materials should not itself be "dirt cheap". He frequently fails to appreciate that in order to make a product such as nylon from "coal, air and water," many intricate chemical reactions must be carried out, involving elaborate and costly equipment, with rigid control at each and every step of the progress.

A Mirror Lake Episode

Campus officer: "Young man are you going to kiss that girl?"

Student: "No sir."

Officer: "All right then, hold my flashlight."

"Well," remarked a friend after inspecting a friend's new yacht, "I wish I could afford a place like this."

"Yes," replied the first, "You married men have the better halves, but we bachelors usually have the better quarters."

And then there was the Ceramic that was so lazy that he could not decide whether to stay in bed all morning or to get up so he'd have a longer day to loaf.

Never run after a woman or a street car; there will be another one along soon anyhow.

Joe: "You know, I like mathematics, when it's not over my head."

Naturalist: "Yea, that's the way I feel about pigeons."

A young lady in the street car was vainly trying to cover her knees with an abbreviated skirt, when an old toper, seated across the aisle, remarked: "That's all right, lady, my weakness is liquor."—Ohio State Engr., Feb. 1930.

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"And the barometer—how much is it Abie?"

"Oi, it's a bargain, only 29.95."